

What is claimed is:

1. A method for processing information in a management application, the method  
5 comprising the steps of:
  - receiving load information from a plurality of store processes, the load  
information indicating a relative processing load for respective store processes in the  
plurality of store processes;
  - 10 determining store process availability of the plurality of store processes based on  
the received load information;
  - receiving a store assignment request from an agent that has an agent transaction to  
perform with a store process; and
  - 15 assigning a store process of the plurality of store processes for the agent to use to  
perform the agent transaction based on the determined store process availability.
2. The method of claim 1 wherein determining store process availability of the plurality  
of store processes based on the received load information comprises:
  - for each store process of the plurality of store processes:
    - 20 i) if the load information for that store process is within an acceptable  
threshold load factor range, identifying that store process as an available store  
process within the plurality of store processes; and
    - ii) if the load information for that store process is not within an acceptable  
threshold load factor range, identifying that store process as an unavailable store  
process within the plurality of store processes.
- 25 3. The method of claim 2 comprising:
  - identifying a non-available store condition in which load information for all store  
processes of the plurality of store processes is not within an acceptable threshold load  
factor; and
  - 30 during the non-available store condition, in response to receiving a store  
assignment request from an agent, maintaining an agent wait table containing an agent

entries identifying store assignment requests associated with the agents, each agent entry in the agent wait table identifying corresponding wait times for agents that have supplied store assignment requests for processing an agent transaction with a store processes.

5 4. The method of claim 3 wherein maintaining the agent wait table comprises:

if a wait time for an agent identified in an agent entry in the agent wait table exceeds an agent wait threshold, identifying that agent entry in the agent wait table as a starving agent entry.

10 5. The method of claim 4 wherein assigning a store process of the plurality of store processes for the agent to use to perform the transaction based on the determined store process availability comprises:

if there is at least one starving agent entry identified in the agent wait table, and if the store assignment request is received from an agent associated with a starving agent entry, and if there is at least one store process of the plurality of store processes that is identified as an available store process, then:

20 i) assigning an available store process of the plurality of store processes that has the most favorable load information as a selected store process for use in processing the agent transaction for the agent identified in the starving agent entry in the agent wait table; and

ii) forwarding a store assignment response identifying the selected store process to the agent providing the store assignment request corresponding to the starving agent entry in the agent wait table; and

iii) removing the starving agent entry from the agent wait table.

25

6. The method of claim 5 wherein assigning a store process of the plurality of store processes for the agent to use to perform the transaction based on the determined store process availability comprises:

30 if there is at least one starving agent entry identified in the agent wait table and the store assignment request is received from an agent that is not associated with a starving agent entry, then:

i) updating the agent entry associated with the agent that provided the store assignment request in the agent wait table to indicate receipt of the store assignment request; and

5 ii) skipping assignment of an available store process to the agent that provided the store assignment request in order to wait for receipt of a store assignment request from an agent associated with a starving agent entry in the agent wait table.

7. The method of claim 6 wherein maintaining the agent wait table comprises:  
10 identifying when an agent entry in the agent wait table has received no store assignment requests for a predetermined agent timeout period and in response, identifying the agent entry associated with that agent in the agent wait table as a non-responding agent.

8. The method of claim 2 wherein assigning a store process of the plurality of store  
15 processes for the agent to use to perform the transaction based on the determined store process availability comprises:  
determining if there is at least one store process of the plurality of store processes that is identified as an available store process, and if so:

20 i) assigning a store process of the plurality of store processes that has the most favorable load information as a selected store process for use in processing the agent transaction for the agent; and  
ii) forwarding a store assignment response identifying the selected store process to the agent providing the store assignment request.

25 9. The method of claim 1 comprising:

repeating receiving load information, determining store process availability,  
receiving a store assignment request from an agent and assigning a store process such that, over time, assignment of store processes to handle processing of agent transactions is load balanced across the plurality of store processes based on the load information  
30 from the store processes.

10. The method of claim 9 wherein assigning a store process of the plurality of store processes for the agent to use to perform the agent transaction based on the determined store process availability comprises:

- 5 after assignment of the store process for the agent to use, establishing a recently assigned agent condition associated with that store process;
  - on a successive iteration of assigning a store process, if the recently assigned agent condition associated with store process is still established, selecting a store process for processing the agent transaction other than the store process to which the recently assigned agent condition applies; and
- 10 clearing the recently assigned agent condition after a predetermined agent assignment interval has elapsed.

11. The method of claim 10 wherein:

- 15 the load information received from the plurality of store process includes a current collective transaction weight of all currently assigned transactions for each store process; and
  - the store assignment request received from the agent has an associated transaction weight of the agent transaction to be performed with a store process;
  - and wherein assigning a store process of the plurality of store processes for the agent to use to perform the agent transaction comprises:
    - 20 for each available store process, calculating a new collective transaction weight as a sum of the current collective transaction weight and the transaction weight of the agent transaction to be performed with a store process;
    - determining if there is at least one store process of the plurality of store processes that has a new collective transaction weight that is within an acceptable collective transaction weight, and if so:
      - 25 i) assigning a store process of the plurality of store processes that has the new collective transaction weight that is within an acceptable collective transaction weight as a selected store process for use in processing the agent transaction for the agent; and
- 30

ii) forwarding a store assignment response identifying the selected store process to the agent providing the store assignment request.

12. The method of claim 9 wherein:

5       the management application is a storage area network management application;  
      the store assignment requests are received from agent processes operating on host computer systems in the storage area network that collect management data on behalf of managed entities associated with the agent processes, the agent processes transferring the management data within agent transactions to store processes to which they are assigned;  
10     and

      the plurality of store processes operate to process the agent transactions to store the management data into a management database on behalf of the plurality of agent processes.

15     13. A method for processing information in a management application, the method comprising the steps of:

      receiving an agent transaction to be processed in a store process, the agent transaction having an associated transaction weight;

      calculating a current collective transaction weight of all agent transactions  
20     currently being processed in the store process;

      calculating a new collective transaction weight as a sum of the current collective transaction weight and the transaction weight of the agent transaction to be performed with a store process;

      if the new collective transaction weight is not within an acceptable collective  
25     transaction weight threshold, then queuing the agent transaction in an agent transaction queue; and

      if the new collective transaction weight is within an acceptable collective transaction weight threshold, then processing the agent transaction within the store process to convert management data in the agent transaction request into managed object  
30     data in a management database accessed by a management application.

14. The method of claim 13 further comprising:

determining when the current collective transaction weight is within an acceptable collective transaction weight threshold, and in response:

- 5 i) selecting an agent transaction from the agent transaction queue to be processed by the store process that has an associated transaction weight that, when summed with the current collective transaction weight produces a new collective transaction weight that is within an acceptable collective transaction weight threshold; and
- ii) removing the processed agent transaction from the agent transaction queue.

10 15. The method of claim 14 further comprising:

calculating load information based on current resource utilization within the store process; and

periodically providing the load information to a load manager process for use by the load manager process in making load balancing decisions for the assignment of store processes for use in processing agent transactions on behalf of agent processes.

16. A computer system comprising:

- a memory;
- a processor;
- 20 a communications interface;

an interconnection mechanism coupling the memory, the processor and the communications interface;

wherein the memory is encoded with a load manager application that when performed on the processor, provides a load manager process for processing information in a management application, the load manager process causing the computer system to perform the operations of:

receiving, via the communications interface into the memory, load information from a plurality of store processes, the load information indicating a relative processing load for respective store processes in the plurality of store processes;

30 determining, via the processor, store process availability of the plurality of store processes based on the received load information;

receiving, via the communications interface into the memory, a store assignment request from an agent that has an agent transaction to perform with a store process; and

assigning, via the processor, a store process of the plurality of store processes for the agent to use to perform the agent transaction based on the determined store process

5 availability.

17. The computer system of claim 16 wherein when the load manager process causes the computer system to perform the operation of determining store process availability of the plurality of store processes based on the received load information, the load manager

10 process causes the computer system to perform the operations of:

for each store process of the plurality of store processes:

i) if the load information for that store process is within an acceptable threshold load factor range, identifying that store process as an available store process within the plurality of store processes; and

15 ii) if the load information for that store process is not within an acceptable threshold load factor range, identifying that store process as an unavailable store process within the plurality of store processes.

18. The computer system of claim 17 wherein the load manager process causes the computer system to perform the operations of:

20 identifying a non-available store condition in which load information for all store processes of the plurality of store processes is not within an acceptable threshold load factor; and

25 during the non-available store condition, in response to receiving a store assignment request from an agent, maintaining an agent wait table containing an agent entries identifying store assignment requests associated with the agents, each agent entry in the agent wait table identifying corresponding wait times for agents that have supplied store assignment requests for processing an agent transaction with a store processes.

19. The computer system of claim 18 wherein when the load manager process causes the computer system to perform the operation of maintaining the agent wait table, the load manager process causes the computer system to perform the operation of:

5 if a wait time for an agent identified in an agent entry in the agent wait table exceeds an agent wait threshold, identifying that agent entry in the agent wait table as a starving agent entry.

20. The computer system of claim 19 wherein when the load manager process causes the computer system to perform the operation of assigning a store process of the plurality of  
10 store processes for the agent to use to perform the transaction based on the determined store process availability, the load manager process causes the computer system to perform the operations of:

determining if there is at least one starving agent entry identified in the agent wait table, and if the store assignment request is received from an agent associated with a  
15 starving agent entry, and if there is at least one store process of the plurality of store processes that is identified as an available store process, then:

i) assigning an available store process of the plurality of store processes that has the most favorable load information as a selected store process for use in processing the agent transaction for the agent identified in the starving agent entry  
20 in the agent wait table; and

ii) forwarding a store assignment response identifying the selected store process to the agent providing the store assignment request corresponding to the starving agent entry in the agent wait table; and

iii) removing the starving agent entry from the agent wait table.

25

21. The computer system of claim 20 wherein when the load manager process causes the computer system to perform the operation of assigning a store process of the plurality of store processes for the agent to use to perform the transaction based on the determined store process availability, the load manager process causes the computer system to  
30 perform the operations of:



if there is at least one starving agent entry identified in the agent wait table and the store assignment request is received from an agent that is not associated with a starving agent entry, then:

- 5 i) updating the agent entry associated with the agent that provided the store assignment request in the agent wait table to indicate receipt of the store assignment request; and
- ii) skipping assignment of an available store process to the agent that provided the store assignment request in order to wait for receipt of a store assignment request from an agent associated with a starving agent entry in the agent wait table.

10

22. The computer system of claim 21 wherein when the load manager process causes the computer system to perform the operation of maintaining the agent wait table, the load manager process causes the computer system to perform the operation of:

- 15 identifying when an agent entry in the agent wait table has received no store assignment requests for a predetermined agent timeout period and in response, identifying the agent entry associated with that agent in the agent wait table as a non-responding agent.

23. The computer system of claim 17 wherein when the load manager process causes the computer system to perform the operation of assigning a store process of the plurality of store processes for the agent to use to perform the transaction based on the determined store process availability, the load manager process causes the computer system to perform the operation of:

- 25 determining if there is at least one store process of the plurality of store processes that is identified as an available store process, and if so:

- i) assigning a store process of the plurality of store processes that has the most favorable load information as a selected store process for use in processing the agent transaction for the agent; and
- ii) forwarding a store assignment response identifying the selected store process to the agent providing the store assignment request.

30

24. The computer system of claim 16 comprising:

repeating receiving load information, determining store process availability,  
receiving a store assignment request from an agent and assigning a store process such  
that, over time, assignment of store processes to handle processing of agent transactions  
5 is load balanced across the plurality of store processes based on the load information  
from the store processes.

25. The computer system of claim 24 wherein assigning a store process of the plurality  
of store processes for the agent to use to perform the agent transaction based on the  
10 determined store process availability, the load manager process causes the computer  
system to perform the operations of:

after assignment of the store process for the agent to use, establishing a recently  
assigned agent condition associated with that store process;

on a successive iteration of assigning a store process, if the recently assigned  
15 agent condition associated with store process is still established, selecting a store process  
for processing the agent transaction other than the store process to which the recently  
assigned agent condition applies; and

clearing the recently assigned agent condition after a predetermined agent  
assignment interval has elapsed.

20

26. The computer system of claim 25 wherein:

the load information received from the plurality of store process includes a current  
collective transaction weight of all currently assigned transactions for each store process;  
and

25

the store assignment request received from the agent has an associated transaction  
weight of the agent transaction to be performed with a store process;

and wherein when the load manager process causes the computer system to  
perform the operation of assigning a store process of the plurality of store processes for  
the agent to use to perform the agent transaction, the load manager process causes the  
30 computer system to perform the operations of:

for each available store process, calculating a new collective transaction weight as a sum of the current collective transaction weight and the transaction weight of the agent transaction to be performed with a store process;

determining if there is at least one store process of the plurality of store processes that has a new collective transaction weight that is within an acceptable collective transaction weight, and if so:

i) assigning a store process of the plurality of store processes that has the new collective transaction weight that is within an acceptable collective transaction weight as a selected store process for use in processing the agent transaction for the agent; and

ii) forwarding a store assignment response identifying the selected store process to the agent providing the store assignment request.

27. The computer system of claim 24 wherein:

the management application is a storage area network management application; the store assignment requests are received from agent processes operating on host computer systems in the storage area network that collect management data on behalf of managed entities associated with the agent processes, the agent processes transferring the management data within agent transactions to store processes to which they are assigned;

and

the plurality of store processes operate to process the agent transactions to store the management data into a management database on behalf of the plurality of agent processes.

28. A computer system comprising:

a memory;

a processor;

a communications interface;

an interconnection mechanism coupling the memory, the processor and the

communications interface;

- wherein the memory is encoded with a store application that when performed on the processor, provides a store process for processing information in a management application, the store process causing the computer system to perform the operations of:
- receiving, via the communications interface, an agent transaction to be processed
  - 5 by the store process, the agent transaction having an associated transaction weight;
  - calculating, via the processor, a current collective transaction weight of all agent transactions currently being processed in the store process;
  - calculating, via the processor, a new collective transaction weight as a sum of the current collective transaction weight and the transaction weight of the agent transaction to
  - 10 be performed with a store process;
  - if the new collective transaction weight is not within an acceptable collective transaction weight threshold, then queuing the agent transaction in an agent transaction queue in the memory; and
  - if the new collective transaction weight is within an acceptable collective
  - 15 transaction weight threshold, then processing the agent transaction within the store process to convert management data in the agent transaction request into managed object data in a management database coupled to the computer system and accessed by the management application.
- 20 29. The computer system of claim 28 wherein the store process causes the computer system to perform the operations of:
- determining when the current collective transaction weight is within an acceptable collective transaction weight threshold, and in response:
    - i) selecting an agent transaction from the agent transaction queue to be processed
    - 25 by the store process that has an associated transaction weight that, when summed with the current collective transaction weight produces a new collective transaction weight that is within an acceptable collective transaction weight threshold; and
    - ii) removing the processed agent transaction from the agent transaction queue.
- 30 30. The computer system of claim 29 wherein the store process causes the computer system to perform the operations of:

calculating load information based on current resource utilization within the store process; and

periodically providing the load information to a load manager process for use by the load manager process in making load balancing decisions for the assignment of store processes for use in processing agent transactions on behalf of agent processes.

31. A computer system comprising:

a memory;  
a processor;  
a communications interface;  
an interconnection mechanism coupling the memory, the processor and the communications interface;

wherein the memory is encoded with a load manager application that when performed on the processor, provides a load manager process for processing information in a management application, the computer system including:

means for receiving, via the communications interface into the memory, load information from a plurality of store processes, the load information indicating a relative processing load for respective store processes in the plurality of store processes;

means for determining, via the processor, store process availability of the plurality of store processes based on the received load information;

means for receiving, via the communications interface into the memory, a store assignment request from an agent that has an agent transaction to perform with a store process; and

means for assigning, via the processor, a store process of the plurality of store processes for the agent to use to perform the agent transaction based on the determined store process availability.

32. A computer system comprising:

a memory;  
a processor;  
a communications interface;

an interconnection mechanism coupling the memory, the processor and the communications interface;

wherein the memory is encoded with a store application that when performed on the processor, provides a store process for processing information in a management

5 application, the computer system including:

means for receiving, via the communications interface, an agent transaction to be processed by the store process, the agent transaction having an associated transaction weight;

10 means for calculating, via the processor, a current collective transaction weight of all agent transactions currently being processed in the store process;

means for calculating, via the processor, a new collective transaction weight as a sum of the current collective transaction weight and the transaction weight of the agent transaction to be performed with a store process;

15 means for determining if the new collective transaction weight is not within an acceptable collective transaction weight threshold, and if so, then means for queuing the agent transaction in an agent transaction queue in the memory; and

20 means for determining if the new collective transaction weight is within an acceptable collective transaction weight threshold, and if so, then means for processing the agent transaction within the store process to convert management data in the agent transaction request into managed object data in a management database coupled to the computer system and accessed by the management application.

33. A computer program product having a computer-readable medium including computer program logic encoded thereon that, when executed on a computer system  
25 provides a method for processing information in a management application by causing the computer system to perform the operations of: -

receiving load information from a plurality of store processes, the load information indicating a relative processing load for respective store processes in the plurality of store processes;

30 determining store process availability of the plurality of store processes based on the received load information;

receiving a store assignment request from an agent that has an agent transaction to perform with a store process; and

assigning a store process of the plurality of store processes for the agent to use to perform the agent transaction based on the determined store process availability.

5

34. A computer program product having a computer-readable medium including computer program logic encoded thereon that, when executed on a computer system provides a method for processing information in a management application by causing the computer system to perform the operations of:

10 receiving an agent transaction to be processed in a store process, the agent transaction having an associated transaction weight;

calculating a current collective transaction weight of all agent transactions currently being processed in the store process;

15 calculating a new collective transaction weight as a sum of the current collective transaction weight and the transaction weight of the agent transaction to be performed with a store process;

if the new collective transaction weight is not within an acceptable collective transaction weight threshold, then queuing the agent transaction in an agent transaction queue; and

20 if the new collective transaction weight is within an acceptable collective transaction weight threshold, then processing the agent transaction within the store process to convert management data in the agent transaction request into managed object data in a management database accessed by a management application.

25